

CLAIMS

1. A vehicle with a lean and alignment control system, comprising:
a frame having a central longitudinal axis and an upright axis that is adapted to be
5 generally perpendicular to a surface on which the vehicle rests when the frame is in a neutral
position with no net leaning loads applied;
a suspension comprising a plurality of arm assemblies connected to the frame;
a mechanical feedback mechanism forming an interconnection between the frame and
the suspension;

10 wherein each arm assembly comprises:
a lower arm having an inboard end and an outboard end;
an upper control arm having an inboard end and an outboard end; and
an actuator mounted to the lower arm and motively connected to the upper
control arm.

15 2. The vehicle of claim 1, wherein the actuator further comprises:
an actuator arm pivotally connected to the inboard end of the upper control arm;
the actuator arm pivotally connected to the inboard end of the lower arm; and
a mechanical drive mechanism motively connected to the actuator arm to move the
20 actuator arm through a range of motion.

3. The vehicle of claim 2, wherein the mechanical feedback mechanism comprises a
position indicating cam operably associated with the arm assembly for automatically
controlling the mechanical drive mechanism and the actuator arm.

25 4. The vehicle of claim 3, wherein:
the position indicating cam comprises an eccentric fixed to rotate with the lower arm;
and
the mechanical drive mechanism comprises an actuation cylinder mounted to the
30 frame and receiving an input from the eccentric as the lower arm moves.

5. The vehicle of claim 4, wherein the mechanical drive mechanism further comprises:

the actuation cylinder in fluid communication with a fluid driven rack and pinion; and
5 a fluid driven rack and pinion drivingly connected to the actuator.

6. The vehicle of claim 5, wherein the mechanical drive mechanism further comprises:

the actuation cylinder fluidly connected to the fluid driven rack and pinion by a high
10 pressure fluid line containing a substantially noncompressible fluid; and
a fluid reservoir in the high pressure fluid line for receiving excess fluid during
periods of high flow rate.

7. The vehicle of claim 6, wherein the reservoir is an expansible reservoir having an
15 adjustable spring for adjusting an expansibility of the reservoir.

8. The vehicle of claim 5, wherein the mechanical drive mechanism further comprises:

the actuation cylinder fluidly connected to the fluid driven rack and pinion by a high
20 pressure fluid line containing a substantially noncompressible fluid; and
a pressure control valve in the high pressure fluid line for adjusting a flow aperture
through which the fluid flows.

9. The vehicle of claim 8, wherein the pressure control valve comprises a needle
25 valve for adjusting the flow aperture and a pop off valve for releasing the fluid at pressures
greater than a predetermined threshold.

10. The vehicle of claim 5, wherein the mechanical drive mechanism further comprises:

the actuation cylinder fluidly connected to a first side of the fluid driven rack and pinion by a high pressure fluid line;

5 the actuation cylinder fluidly connected to a second side of the fluid driven rack and pinion by a low pressure fluid line.

11. The vehicle of claim 2, wherein:

10 the arm assembly is a first arm assembly, the vehicle further comprising a plurality of similar arm assemblies including the first arm assembly;

the mechanical feedback mechanism is a first mechanical feedback mechanism, the vehicle further comprising a plurality of similar feedback mechanisms operatively associated with respective arm assemblies; and

15 each mechanical feedback mechanism comprises a position indicating cam operably associated with the respective arm assemblies for automatically controlling the mechanical drive mechanism and the actuator arm in each arm assembly.

12. The vehicle of claim 11, wherein the plurality of arm assemblies comprises:

at least a first arm assembly on a first side of the frame;

20 at least a second arm assembly on a second side opposite to the first side; and

wherein the mechanical feedback mechanisms automatically move the first arm assembly through a first lean angle closer to the frame and the second arm assembly away from the frame so that the first and second arm assemblies remain generally parallel to each other in response to a leaning force applied by a rider of the vehicle.

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13. The vehicle of claim 11, further comprising:

at least one speed sensor operably associated with the vehicle and adapted for detecting the vehicle speed;

5 a mechanism for automatically adjusting an expansibility in a fluid reservoir based on the vehicle speed; and

wherein the mechanical feedback mechanisms control the fluid driven rack and pinions in each arm assembly and move the actuator arms to provide a smooth lean of the frame relative to the arm assemblies.

10 14. The vehicle of claim 2, further comprising:

a shock absorber having an inboard end and an outboard end;

the inboard end of the shock absorber connected to the frame; and

the outboard end of the shock absorber connected to the actuator arm.

15 15. The vehicle of claim 14, wherein the shock absorber is connected to the actuator arm outboard relative to a position at which the upper control arm is connected to the actuator arm.

20 16. The vehicle of claim 14, wherein the shock absorber moves in a range of motion between:

a first position in which the shock absorber extends in an end to end direction substantially parallel with the lower arm of a first arm assembly of the plurality of arm assemblies when the frame is leaned away from the first arm assembly; and

25 a second position having an angle of approximately forty-five degrees relative to the lower arm of the first arm assembly when the frame is leaned toward the first arm assembly.

17. The suspension of claim 14, wherein the outboard end of the shock absorber moves in a range of motion between a position generally above the upper control arm to a position generally below the upper control arm.

18. The vehicle of claim 2, wherein the actuator arm comprises:

a first connection comprising structure that pivotally connects the actuator arm to the lower arm;

5 a second connection comprising structure that pivotally connects the actuator arm to the upper control arm;

a third connection that connects a shock absorber to the actuator arm; and

wherein a line through the first connection and the second connection is at an angle in a range substantially from 0 to 90 degrees relative to a line through the first connection and the third connection.

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19. The vehicle of claim 18, wherein the angle is approximately forty-five degrees.

20. The vehicle of claim 18, wherein the third connection is outboard of the second connection.

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21. In a vehicle, a method of tracking a contour of a driving surface to absorb shock, the method comprising:

automatically and independently raising and lowering a plurality of arms of the vehicle suspension to accommodate variations in the contour by a mechanical mechanism;

20 providing feed forward by at least one mechanical shock absorber;

providing feedback via the mechanical mechanism to an actuator; and

raising and lowering the arms by the actuator according to the feedback.

22. The method of claim 21, wherein the mechanical mechanism comprises a position
25 indicating cam fixedly supported relative to at least one of the arms, and wherein the step of providing feedback further comprises feeding back a representation of a position of the at least one of the arms by way of the cam.

23. The method of claim 21, comprising providing additional feed forward by taking up
30 excess fluid in an expansible reservoir in fluid communication with the mechanical mechanism.

24. A vehicle suspension, comprising:

- a lower arm having an inboard end and an outboard end;
- an upper control arm having an inboard end and an outboard end;
- 5 an actuator comprising a drive mechanism and at least one actuator arm;
- the actuator arm pivotally connected to the lower arm;
- the actuator arm pivotally connected to the upper control arm; and
- the drive mechanism connected to the actuator arm.

10 25. The vehicle suspension of claim 24, further comprising:

a cammed cylinder in fluid communication with an actuation mechanism that at least partially controls the actuator arm;

wherein the actuator is motively connected to at least one of the lower arm and the
15 upper control arm by the actuator arm

26. The vehicle suspension of claim 25, wherein the actuation mechanism comprises a mechanical shock absorber and an actuator line connects the cammed cylinder to the mechanical shock absorber.

20 27. The vehicle suspension of claim 24, further comprising a mechanical shock absorber pivotally connected to the actuator arm.

28. The vehicle suspension of claim 27, further comprising:

- 25 a cam member supported on the lower arm;
- a cammed cylinder having a piston motively coupled to the cam member; and
- an actuator line connecting the cammed cylinder to the mechanical shock absorber.

29. The vehicle suspension of claim 24, further comprising a mechanical link pivotally
30 connected to the actuator arm.

30. The vehicle suspension of claim 24, further comprising a hub assembly pivotally connected to the outboard ends of the lower arm and the upper control arm, wherein pivotal connections of the actuator arm, the lower arm, the upper control arm, and the hub assembly generally form a parallelogram.

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31. The vehicle suspension of claim 24, further comprising:

an actuator pump coupled to an actuator feed line;

wherein:

the actuator comprises a cylinder having a piston motively coupled to the
actuator feed line;

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one of the cylinder and the piston is supported on one of the lower arm and the upper control arm; and

the other of the piston and the cylinder is motively connected to the actuator arm.

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32. A frame and suspension for a vehicle, comprising:

a frame;

a lower arm having an inboard end coupled to the frame and an outboard end;

an upper control arm having an inboard end and an outboard end;

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an actuator comprising a drive mechanism and at least one actuator arm;

the actuator arm pivotally connected to the lower arm;

the actuator arm pivotally connected to the upper control arm; and

the drive mechanism connected to the actuator arm.

25 33. The frame and suspension for a vehicle of claim 32, further comprising:

a cammed cylinder having a piston in fluid communication with an actuation mechanism that at least partially controls the actuator arm;

wherein the actuator is motively connected to at least one of the lower arm and the upper control arm by the actuator arm

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34. The frame and suspension for a vehicle of claim 33, wherein the actuation mechanism comprises a mechanical shock absorber and the actuator line connects the cammed cylinder to the mechanical shock absorber.

5 35. The frame and suspension for a vehicle of claim 32, further comprising a mechanical shock absorber pivotally connected to the actuator arm.

36. The frame and suspension for a vehicle of claim 35, wherein the mechanical shock absorber is pivotally connected to the frame.

10 37. The frame and suspension for a vehicle of claim 35, further comprising:
a cam member supported on the lower arm;
a cammed cylinder having a piston motively coupled to the cam member; and
an actuator line connecting the cammed cylinder to the mechanical shock absorber.

15 38. The frame and suspension for a vehicle of claim 37, wherein the cammed cylinder is supported on the frame.

39. The frame and suspension for a vehicle of claim 32, further comprising a mechanical link pivotally connected to the actuator arm.

20 40. The frame and suspension for a vehicle of claim 39, wherein the mechanical link is pivotally connected to the frame.

25 41. The frame and suspension for a vehicle of claim 32, further comprising a hub assembly pivotally connected to the outboard ends of the lower arm and the upper control arm, wherein pivotal connections of the actuator arm, the lower arm, the upper control arm, and the hub assembly generally form a parallelogram.

42. The frame and suspension for a vehicle of claim 32, further comprising a mechanical link pivotally connected to each of the actuator arm and the frame, wherein the parallelogram is a first parallelogram and pivotal connections between the mechanical link, the frame, the actuator arm, and the lower arm form a second parallelogram.

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43. The frame and suspension for a vehicle of claim 32, further comprising:

an actuator pump coupled to an actuator feed line;

wherein:

the actuator comprises a cylinder having a piston motively coupled to the actuator feed line;

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one of the cylinder and the piston is supported on one of the lower arm and the upper control arm; and

the other of the piston and the cylinder is motively connected to the actuator arm.

44. The frame and suspension for a vehicle of claim 32, wherein:

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the frame is a vehicle frame;

the suspension comprises the lower arm, the upper control arm, the actuator arm, and the actuator as a first arm assembly; and

wherein the suspension further comprises at least a second arm assembly similar to the first arm assembly.

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45. The frame and suspension for a vehicle of claim 44, wherein each arm assembly includes a cammed cylinder fluidly connected to at least one mechanical shock absorber.

46. The frame and suspension for a vehicle of claim 45, wherein the cammed cylinders have pistons that move therein to provide a greater or lesser effective volume for each shock absorber.

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47. The frame and suspension for a vehicle of claim 46, wherein the effective volume is decreased as the respective arm assembly is rotated through an arc toward the frame.

48. The frame and suspension for a vehicle of claim 46, wherein the effective volume is decreased as the respective arm assembly is rotated through an arc away from the frame.

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